AD-A164 060 FITNESS AND ACTIVITY ASSESSMENTS AMONG US ARMY POPULATIONS: IMPLICATIONS F (U) ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA J A VOGEL JAN 86 1/1

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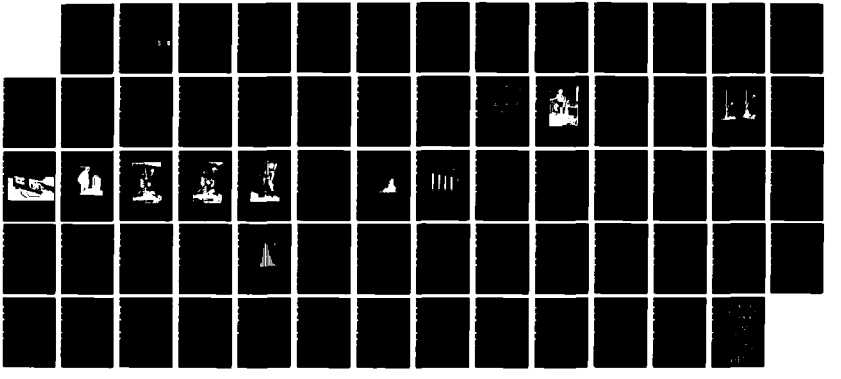

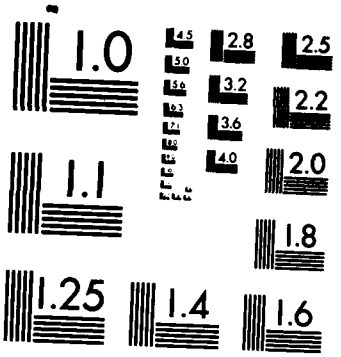

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Chapter 18

Fitness and Activity Assessments among U.S. Army Populations: Implications for NCHS General Population Surveys

by

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HUMAN RESEARCH

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

I INTRODUCTION

A. Background

The military forces of this country represent the largest population for which physical fitness is routinely assessed. "Field" measures of aerobic power, muscle strength and muscular endurance, along with body weight, (and in some cases body fat), are measured twice yearly in the U.S. Army through age 60. Field measures are defined as those conducted by army units without the aid of equipment or indoor facilities. The purpose of these periodic fitness evaluations is both as an indicator of the adequacy of training to meet performance goals as well as a motivator to the individual to train and improve their fitness level.

In addition to these periodic field measures, extensive population surveys of laboratory-measured fitness and activity assessment have been made in a wide variety of Army units over the past ten years by the Exercise Physiology Division, US Army Research Institute of Environmental Medicine. These assessments have been part of an ongoing research program to study factors influencing fitness in the Army. This chapter presents a description of the survey methods and sample data from both approaches.

B. Fitness Components

Fitness components of concern to the Army include aerobic power, muscle strength and strength endurance (anaerobic power). These components were selected to reflect the three categories of muscular contraction based

on their respective sources of energy as illustrated in Figure 1. Motor fitness aspects, such as agility, flexibility and coordination are not typically assessed and will not be included in this discussion.

As an adjunct to fitness concerns, body weight and body composition are also included as fitness components in the military. Body weight and fat standards were originally part of the fitness program and fitness regulations. Because of a considerable increase in emphasis in this area, they are now considered under separate regulations.

C. Objective

The purpose of this chapter is to document the methodologies used by the Army to evaluate fitness both in the field and in the laboratory and present a compilation of available data from both sources. Body composition procedures and example data are also presented. Finally, a number of physical activity assessment questionnaires that have been employed in Army studies are included.

II. Field Assessment of Fitness

A. Background

The Army has conducted periodic assessments of fitness of its soldiers since World War Two although the specific test events, standards, applicable population and frequency have varied over the years. Prior to 1980 a five event fitness test was administered for men which included an inverted crawl, run-dodge-jump, horizontal ladder, bent-leg situp and two

Categories of Physical Fitness

PATHWAY	ANAEROBIC		AEROBIC
ENERGY SOURCE/ PATHWAY	PHOSPHOGENS/ PHOS. SPLITTING	GLYCOGEN/ GLYCOLYSIS	LIPIDS/ CITRIC ACID CYCLE
PRIMARY DETERMINANT	MUSCLE MASS	MUSCLE FIBER MAKE-UP	OXYGEN TRANSPORT
NATURE	VERY HIGH INTENSITY 1-5 SECONDS	HIGH INTENSITY 5-60 SECONDS	MODERATE-LOW INTENSITY > 1 MINUTE
EXAMPLE OF ACTIVITIES	LIFT PUSH PULL	DIGGING SPRINTING CLIMBING	RUNNING LOAD BEARING WALKING
PHYSIOLOGICAL TERMINOLOGY	MAXIMAL FORCE MAXIMAL TORQUE PEAK POWER	ANAEROBIC POWER	AEROBIC POWER
COMMON TERMINOLOGY	MUSCLE STRENGTH	MUSCULAR ENDURANCE	STAMINA CARDIOPULMONARY FITNESS

Figure 1. Categories of physical fitness as a function of energy source.

mile run. For women soldiers events consisted of an 80 meter shuttle run, modified pushups, run-dodge-jump, modified situps and a one mile run.

In an attempt to improve and streamline fitness testing, a new testing program was implemented in 1980 which dropped events that did not evaluate physical fitness capacity per se (as opposed to motor fitness) and applied events uniformly to both men and women. With emphasis on eliminating equipment and enhancing the objectivity of scoring, three events were chosen: two mile run for time, maximal number of extended leg pushups and maximal number of bent knee situps that can be performed in a two minute period.

While the two mile run for time can be considered a good estimation of aerobic power (1), pushups and situps leave much to be desired in covering the remaining components of strength and strength endurance. In fact, both of these tests must be considered strength endurance events that are limited only to the shoulder and abdominal muscles. Neither of these events correlate well with common soldiering tasks (2) but nevertheless serve the purpose of stimulating participation in physical training programs.

B. Methods

The three event fitness test, originally called the Army Physical Readiness Test, is now referred to as the Army Physical Fitness Test (APFT). It is required to be taken twice yearly through age 60. Personnel 40 years of age and older must receive a medical clearance to participate in training and testing which consists of a physical examination and coronary disease risk assessment (3).

The test is administered by the soldier's unit or organization and is recorded on a score care (Figure 2) which is retained in the unit's administrative files. Raw scores (time for run and number of pushups and situps) are converted into a relative score. The soldier must achieve the minimum standard in each event which represents 60 points and must also achieve a total of 180 points overall. Minimum passing and maximum score standards have been established (Table 1) and are currently being upgraded (Table 2). These standards are adjusted for gender and age regardless of occupation or assignment. Special units and schools may impose higher standards. Failure to meet the minimum standard for each event and the total score requires repeat testing after a suitable period of remedial training. APFT scores become a part of the individual's annual performance rating.

The procedure for each of the three events is as follows:

Pushup - start from a front leaning rest position with hands and feet comfortably apart, arms extended, body in a straight line. Body is then lowered by bending the elbows to a point where the upper arms are parallel to the ground and then return to the starting position.

Situp - start by lying on back with knees bent at 90 degree angle, ankles held by another individual, hands interlocked behind head. Upper body is raised forward to and pass the vertical position and then lowered back to the ground to the starting position.

2 mile run - time is measured that is required to run a measured two mile course.

C. Findings

ARMY PHYSICAL READINESS TEST SCORECARD

For use of this form, see FM 21-20; the proponent agency is U. S. Army Training and Doctrine Command.

PRINT NAME (Last, First, Middle Initial)	SERVICE NUMBER	GRADE	AGE	HEIGHT	WEIGHT	SEX

PART I. TEST PERFORMANCE REPORT

TEST NUMBER	FIRST TEST		SECOND TEST		THIRD TEST		FOURTH TEST	
DATE OF TEST								
WEATHER CONDITION	TEMP COND		TEMP COND		TEMP COND		TEMP COND	
UNIT (Platoon-Company)								
EVENTS	RAW	POINTS	RAW	POINTS	RAW	POINTS	RAW	POINTS
Pushup								
Situp								
2-mile Run								
TOTAL								
SCORER SIGNATURE	SCORER		SCORER		SCORER		SCORER	

The two Army Physical Readiness Tests contain the three events listed above

1. The Army Physical Readiness Test (Age 17-39)
2. *The Army Physical Readiness Test* (Age 40-60)

DATA REQUIRED BY THE PRIVACY ACT OF 1974

TITLE OF FORM DA FORM 705

AUTHORITY 10USC3012(g)

PRINCIPAL PURPOSE Record of individual's scores on physical readiness events

ROUTINE USE Evaluation of individual's physical readiness

MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION Mandatory. Individuals not providing information cannot be rated/scored

DA FORM 705 OCT 80

Replaces DA Form 705, Nov 72, which is obsolete and rescinds DA Form 705-R (Privacy Act Statement), Sep 75

Figure 2. Data card for recording Army's physical fitness test scores.

Table 1. Army Physical Readiness Test minimum standards (revised after 1 Oct 1986, see table 3)

	Two Mile Run Time		Pushups		Situps	
Age Categfory	Males	Females	Males	Females	Males	Females
17-25	17:55	22:14	40	16	40	27
26-30	18:30	22:29	38	15	38	25
31-35	19:10	24:04	33	14	36	23
36-39	19:35	25:34	32	13	34	21
40-45	20:00	26:00	20	10	25	15
46-50	21:00	27:00	20	10	25	15
51-55	22:00	28:00	15	8	20	10
56-60	23:00	29:00	15	8	20	10

Table 2. New Army Physical Fitness Test minimum standards (as of 1 Oct 1986)

Age Category	Two Mile Run Time		Pushups		Situps	
	Males	Females	Males	Females	Males	Females
17-21	15:45	18:45	42	18	52	50
22-26	16:36	19:36	40	16	47	45
27-31	17:18	21:00	38	15	42	40
32-36	18:00	22:36	33	14	38	35
37-41	18:42	23:36	32	13	33	30
42-46	19:12	24:00	26	12	29	27
47-51	19:36	24:30	22	10	27	24
52+	20:00	25:00	16	9	26	22

Even though the APFT is administered twice yearly to some 700,000 soldiers, these data are not gathered centrally and therefore it is not possible to summarize them. Large population studies have been conducted which have included the collection of APFT results and some samples of these are given here. Table 3 presents APFT scores from a sample of basic initial entry trainees collected in 1983 at the Fort Jackson Training Center. Values are given for both men and women before and after the seven weeks of recruit training. Marked improvement was evident in all events.

Tables 4-6 illustrate APFT data from a cross section of soldiers assigned to a variety of units at a large Army base in 1984 (4). Values are tabulated according gender, age and ethnicity. Percentile values for the entire sample are presented in Table 7.

III. Laboratory Surveys of Fitness

A. Background

Since the inception of the fitness research program at the US Army Research Institute of Environmental Medicine in 1974, a number of Army populations have been sampled for physical fitness using standardized laboratory procedures. Most of these studies have been documented in individual reports (5-9) and have been summarized in two recent publications (10, 11). Some of the larger and more representative surveys are presented in this chapter.

B. Methods

Table 3. Army physical fitness test scores before and after basic initial entry training (Fort Jackson, 1982)

Test event	Time	males n	males mean	males SD	females n	females mean	females SD
Pushup (#/2 min)	Pre-basic	791	27	8	529	8	8
	Post-basic	814	44	11	765	22	9
Situp (#/2 min)	Pre-basic	791	42	13	529	38	13
	Post-basic	815	60	9	765	56	10
1/2 mile run (min)	Pre-basic *	751	7:25	1:58	450	9:38	1:49
	Post-basic **	812	14:06	1:12	757	17:47	:57

*1 mile **2 mile

Table 4. APFT pushup scores for soldiers assigned to a variety of units at at a large Army post (Ref. 4).

	Male				Females			
Category	n	mean	SD	range	n	mean	SD	range
All	1014	50	15	13-99	255	32	12	10-78
17-20 yrs	154	56	11	20-79	60	34	11	17-64
21-27	368	56	13	13-99	146	33	12	15-78
28-39	286	50	12	15-99	48	29	11	12-69
40+	206	36	16	15-80	-	-	-	-
Black	238	53	14	13-99	89	32	11	12-69
Hispanic	120	55	13	20-85	18	35	8	20-46
White	620	48	16	15-99	141	32	12	10-78

Table 5. APFT situp scores for soldiers assigned to a variety of units at a large Army post (Ref 4).

	Males				Females			
Category	n	mean	SD	range	n	mean	SD	range
All	1014	51	14	12-99	255	51	13	16-86
17-20 yrs	154	59	10	35-79	60	55	12	30-81
21-27	366	57	11	28-99	146	52	12	27-86
28-39	287	50	12	12-84	48	43	11	25-74
40+	207	43	17	20-99	-	-	-	-
Black	239	57	12	25-99	89	51	12	26-75
Hispanic	118	55	12	33-84	18	55	10	40-71
White	621	50	15	12-99	141	50	13	16-86

Table 6. APFT 2-mile run scores for soldiers assigned to a variety of units at a Army post (min:sec) (Ref. 4).

	Males				Females			
Category	n	mean	SD	range	n	mean	SD	range
All	1006	14:55	2:05	10:06-24:00	254	17:45	2:21	12:30-27:24
17-20 yrs	152	13:50	1:38	10:06-17:30	59	17:01	2:23	12:30-23:12
21-27	363	14:12	1:48	10:06-19:18	146	17:53	2:01	13:30-23:12
28-39	287	15:40	1:59	10:12-23:00	49	18:16	3:01	13:00-27:24
40+	206	15:53	2:06	11:00-24:00	-	-	-	-
Black	236	14:27	2:06	10:12-23:00	90	17:38	1:58	13:00-23:12
Hispanic	116	14:25	1:52	10:06-20:00	18	16:45	1:54	12:30-21:06
White	618	15:09	2:04	10:12-24:00	139	17:58	2:33	13:00-27:24

Table 7. Percentile values for APFT scores for soldiers assigned to a variety of units at a large Army post (Ref. 4).

	Males			Females		
Percentiles	PU	SU	2m run	PU	SU	2m run
5	20	25	11:30	17	30	14:05
20	40	40	13:06	22	40	16:00
35	45	46	14:00	26	45	17:00
50	50	51	15:00	30	50	17:30
65	55	60	15:30	38	56	18:24
80	65	66	17:00	40	62	19:34
95	72	72	18:18	50	70	21:26

(1) Aerobic Power

Our laboratory typically surveys aerobic fitness by directly measuring maximal O_2 uptake. The interrupted-load, uphill treadmill running procedure is used as originally described by Taylor, et al (12) and Mitchell, et al (13) and illustrated in Figure 3. Although only 12-15 tests can be performed each day per treadmill, we believe that the much greater reliability, reproducibility and consistency justifies this more elaborate procedure, as compared to $\dot{V}O_2max$ prediction procedures, especially when equipment, personnel and space are not overriding constraints. The limitations of prediction techniques are well known (14,15). They tend to give poor estimates at the extremes and are affected by other factors which influence heart rate. Direct measures of $\dot{V}O_2max$ permit the following of individuals through training programs or interventions and the ability to compare groups between studies, all of which are subject to considerable error when using predictive methods. We have also chosen the treadmill running mode of exercise rather than the cycle ergometer for the obvious reasons of application to soldering tasks, avoids the possibility of being compounded by local muscle fatigue and because it results in higher values.

In our procedure, female subjects perform an initial warm-up load at 5 mph (134 m/min) for 6 minutes. This is followed by 3 or 4 additional runs (all separated by 5 minutes of rest) of 4 or 3 minutes in duration at either 5 or 6 mph with increasing increments in grades of 2.5% until a leveling off of $\dot{V}O_2$ is achieved. The leveling off criteria is defined as an increase of less than 0.15 $\ell \cdot min^{-1}$ per 2.5% grade increase. Male subjects follow the same protocol except that they begin at 6 mph (161 m/min) followed by speeds of 6 or 7 mph for subsequent incremental loads. Expired gas is collected for analysis during the final minute of each load.

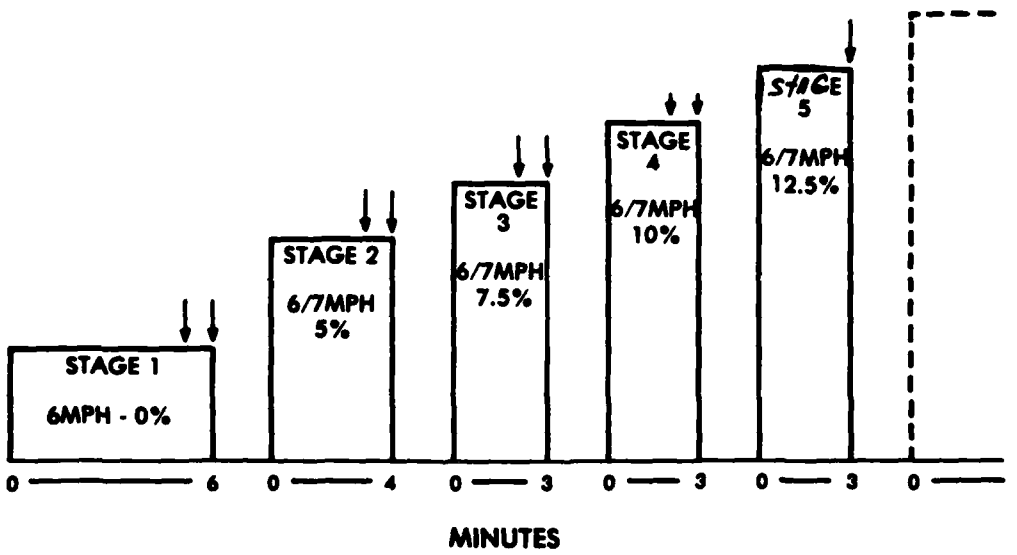


Figure 3. Procedural protocol employed for the actual measurement of maximal oxygen uptake on the treadmill.

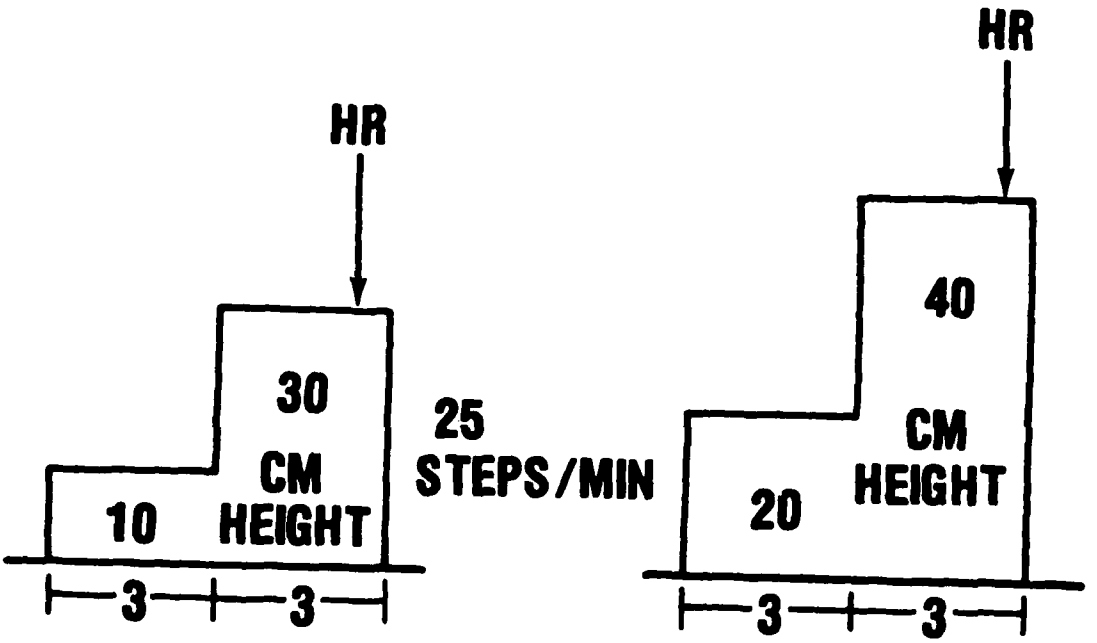
We have found it desirable to depart from this standard protocol when testing over 40 age personnel where we wish to combine electrocardiographic stress evaluation along with aerobic power determination. In this case we employ a continuous uphill walking treadmill protocol to facilitate good quality electrocardiographic traces. It consists of walking at a constant velocity of 3.3 mph (90 m/min) while elevating the treadmill incline 5% every three minutes without intervening rest. $\dot{V}O_2$ is measured as described previously. If $\dot{V}O_2$ does not plateau, the highest $\dot{V}O_2$ achieved is taken to represent $\dot{V}O_2max$.

Although we typically do not utilize predictive techniques in the laboratory for assessing aerobic fitness in the Army, we have examined them for application to initial entry testing for occupational classification. Some of this data is presented here for comparative purposes. The two predictive procedures used included the familiar Astrand-Ryhming cycle ergometer single load test (16) and a step test.

The procedure followed in the cycle ergometer test is as originally described by Astrand and Ryhming in which the subject pedals at a resistance which will result in a heart rate response between 120 and 170 at the end of six minutes. The resistance setting (watts or kilopond meters) and heart rate are applied to a nomogram for the estimation of $\dot{V}O_2max$.

The step test procedure is illustrated in Figure 4. Subjects began by stepping at a cadence of 25 complete steps per minute at a step height of either 10, 20 or 30 cm, depending on an estimate of their fitness level. The heart rate observed at the end of three minutes is used to adjust the load to a higher step for an additional three minutes for the final heart rate reading. A stepping stool with fold-down steps is utilized (Figure 5).

STEPPING TEST



MALE: $\dot{V}O_{2\ MAX} = \frac{195-61}{HR_s - 61} \cdot \dot{V}O_{2\ STEP}$

FEMALE: $\dot{V}O_{2\ MAX} = \frac{198-72}{HR_s - 72} \cdot \dot{V}O_{2\ STEP}$

$\dot{V}O_{2\ STEP}$ 30 CM = 26 ML/KG . MIN.
40 CM = 32 ML/KG . MIN.

Figure 4. Step test procedure for estimation of $\dot{V}O_2$max.

Figure 5. Fold-down stepping stool for step test estimation of $\dot{V}O_2max$.

$\dot{V}O_2$max is again estimated from the observed heart rate and exercise intensity (step height and frequency) (16). In both procedures heart rate is measured electrocardiographically with disposable chest electrodes. We have observed correlation coefficients of 0.63 and 0.64 with actual treadmill $\dot{V}O_2$max for the Astrand-Ryhming cycle and step test procedures, respectively.

(2) Anaerobic power/muscular endurance

Our laboratory has employed two procedures to assess anaerobic power capacity for Army fitness evaluations: the Wingate power test (17,18) and the Thorstensson isokinetic endurance test (20). Both are designed to evaluate the capacity to generate muscular power from the anaerobic glycolytic energy pathways.

The Wingate protocol involves pedalling at maximal velocity for 30 seconds against a resistance based on body weight selected to elicit maximal power output over a 30 second period. The exercise is performed on a modified mechanical braked ergometer (19). The weighted pendulum is replaced by a counter-balanced lever arm to which a weight is attached so that resistance can be applied instantaneously. Resistance applied is 4.41 joules/pedal revolution/kg body weight. After achieving a near maximal pedal rate with no resistance applied, the lever arm is dropped applying the resistance and the subject continues pedaling all-out for 30 seconds. Mean power output over the 30 second period is computed.

For the isokinetic endurance test, the subject performs repeated knee extensions against a lever arm connected to a dynamometer and speed control device that maintains angular velocity at 180 degrees per second (Cybex II apparatus). Fifty knee extension contractions are performed requiring 60 seconds. The mean peak torque over the 50 contractions is computed.

(3) Muscular strength

Muscular strength is a measure of the maximal force that can be generated in a single contractile effort. It may also represent the peak power that can be generated in a dynamic exercise of no longer than 5 seconds, thus measuring only energy that is immediately available within the muscle. We have developed a variety of strength measures for our assessment batteries in order to include various modes of activity and several different muscle groups.

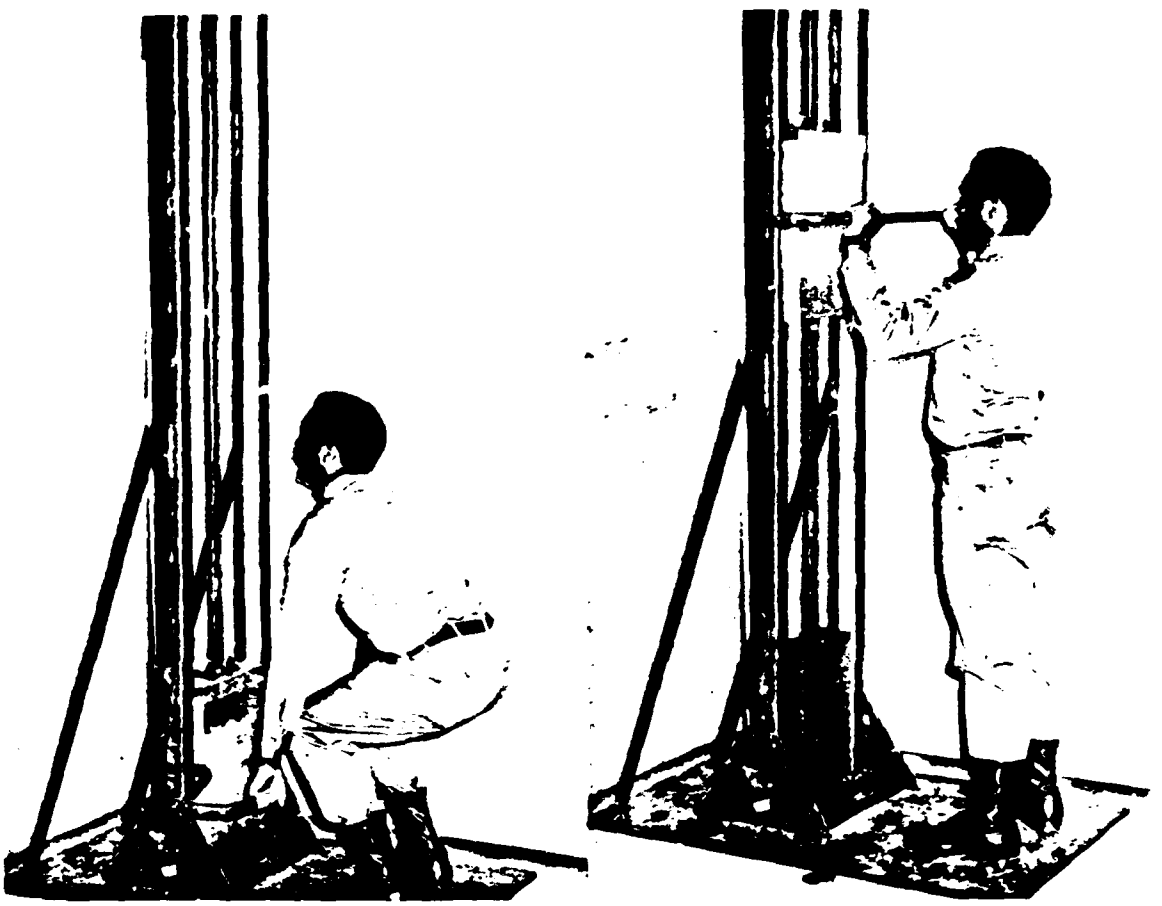
(a) Dynamic - isokinetic

If possible, we prefer to utilize dynamic measures of strength as opposed to static or isometric since most real life tasks are dynamic. Our typical strength assessment battery includes the use of the Cybex II dynamometer and isokinetic apparatus to measure elbow flexion and extension and knee extension and flexion (21). At least two velocities are employed, 30 and 180 degrees per second. The average of three single contractions is recorded.

(b) Dynamic - lift

Also included in our muscle strength battery is a measure of the maximal lift capacity to a height of five or six feet. This represents a total or composite strength of several muscle groups. The procedure (22,23) involves lifting a weighted carriage which rides on a vertical track in incremental steps until the maximum lift weight is achieved (see Figure 6). This procedure is presently employed to screen all new Army and Air Force applicants.

(c) Isometric



a. STARTING POSITION

b. 152cm LIFT

Figure 6. Incremental dynamic lift device used to determine maximal left capacity.

Isometric or static maximal contractions are used in our assessment batteries when time, safety or other constraints may apply. Handgrip maximal force is included since it has been found to correlate well with general body strength (24). We utilize a non-commercial handgrip dynamometer (Figure 7) (21) that includes an adjustable grip surface to account for the 15 degress ulnar deviation of the hand. It is coupled to a load cell transducer.

Since one of the primary strength tasks in the Army is lifting, we also include an isometric 38 cm upright pull force measure (Figure 8) (25). This involves pulling vertically on a bar from a squatting position centered over the force transducer. It measures the strength of many of the muscle groups involved in lifting. Three other isometric measures have been employed: knee extension, trunk extension and upper torso pull down force (26) (Figure 9-11).

C. Findings from Laboratory Surveys

(1) Aerobic power

Most of our Army population surveys of aerobic fitness have been reported recently (10,11). Extracts of these are presented here.

Table 8 presents data for new male and female recruits as they enter the Army. These data are representative of the civilian population entering the military service. Absolute $\dot{V}O_2max$ is 40% less in women but only15% less when adjusted for difference in fat free weight. The relatively small overlap between genders is illustrated in Figure 12. Figure 13 illustrates the typical decrements in $\dot{V}O_2max$ with age in high intensity and

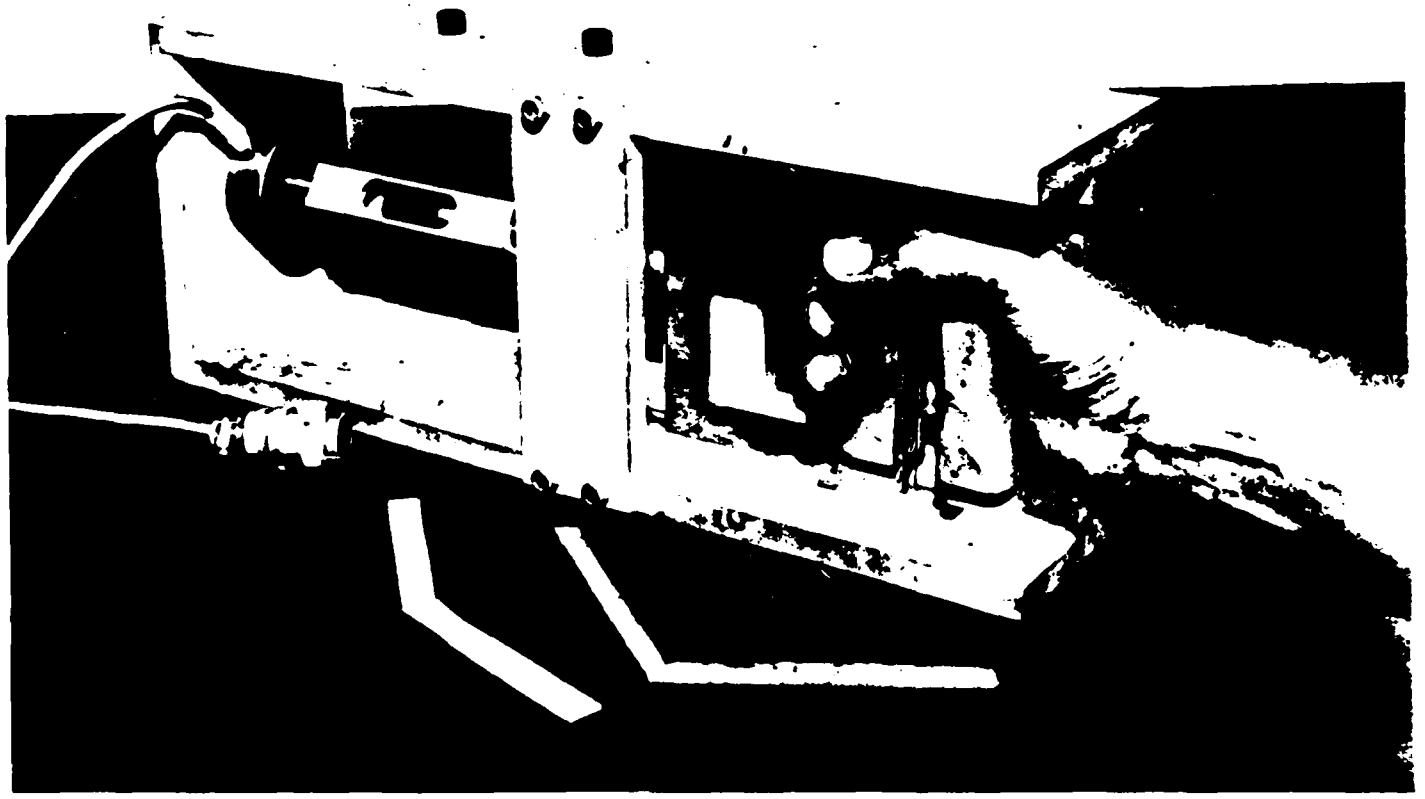


Figure 7. Handgrip device with adjustable grips and load cell transducer.

Figure 8. 38 cm isometric upright pull force device.

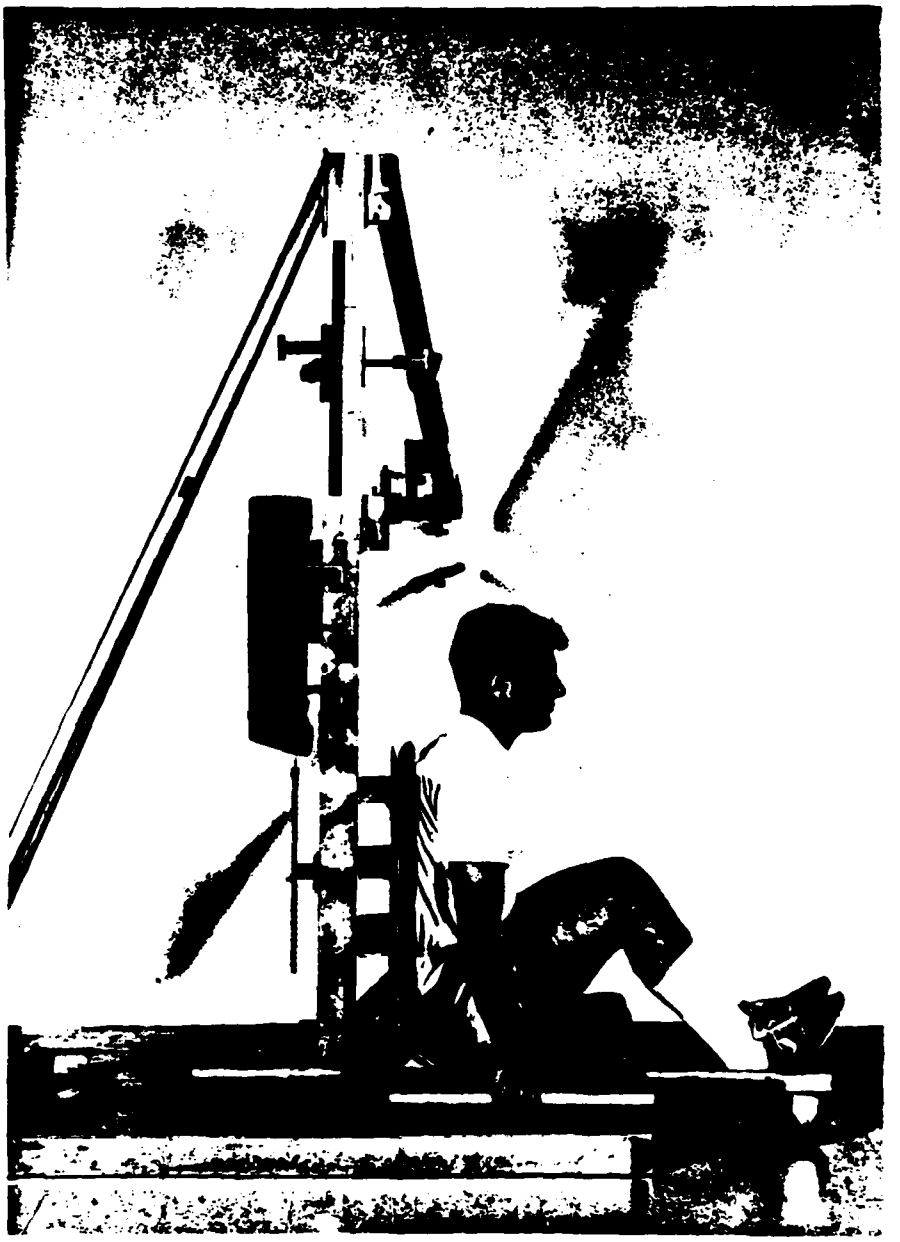


Figure 9. Isometric measurement of knee extension strength.

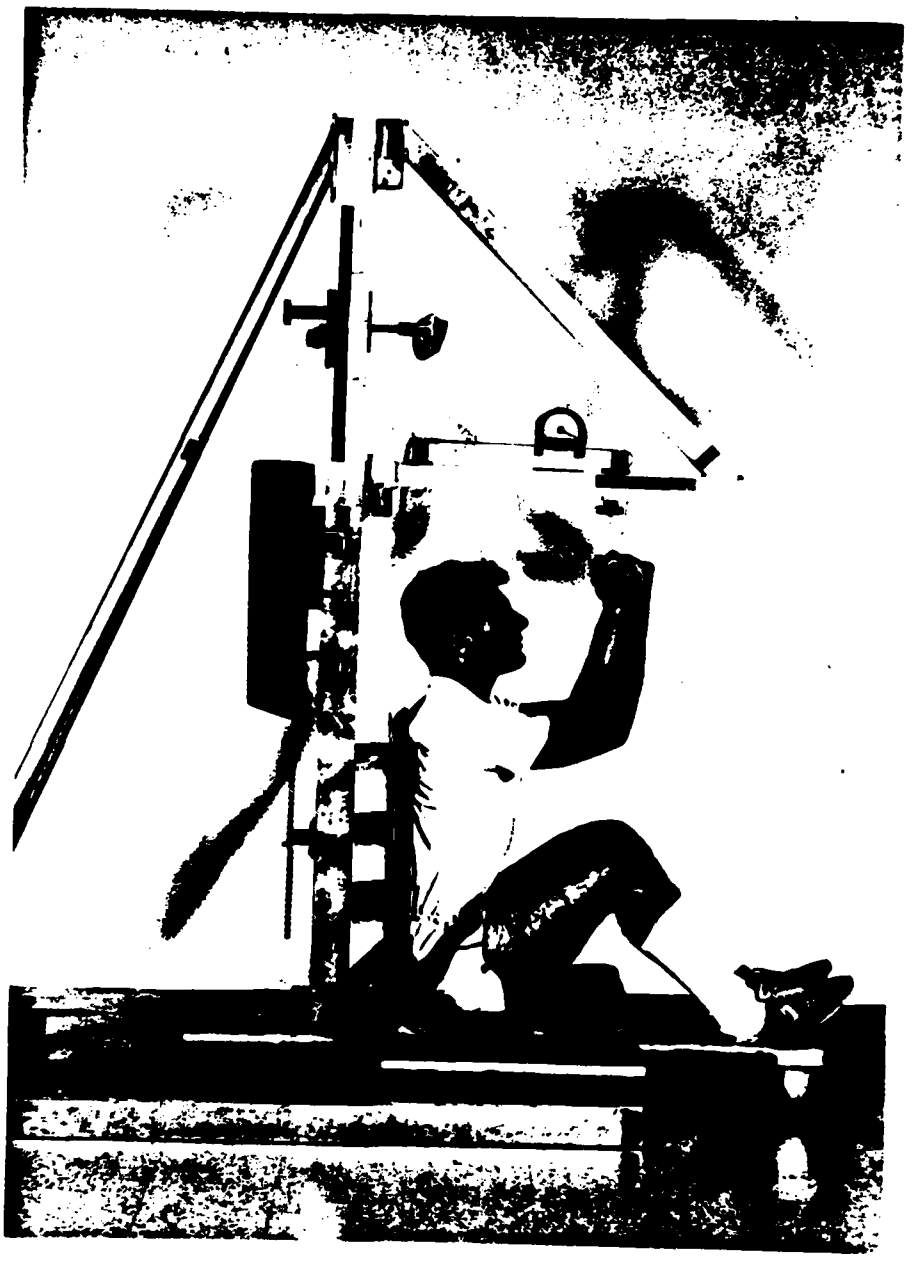


Figure 10. Isometric measurement of soulder-arm strength.

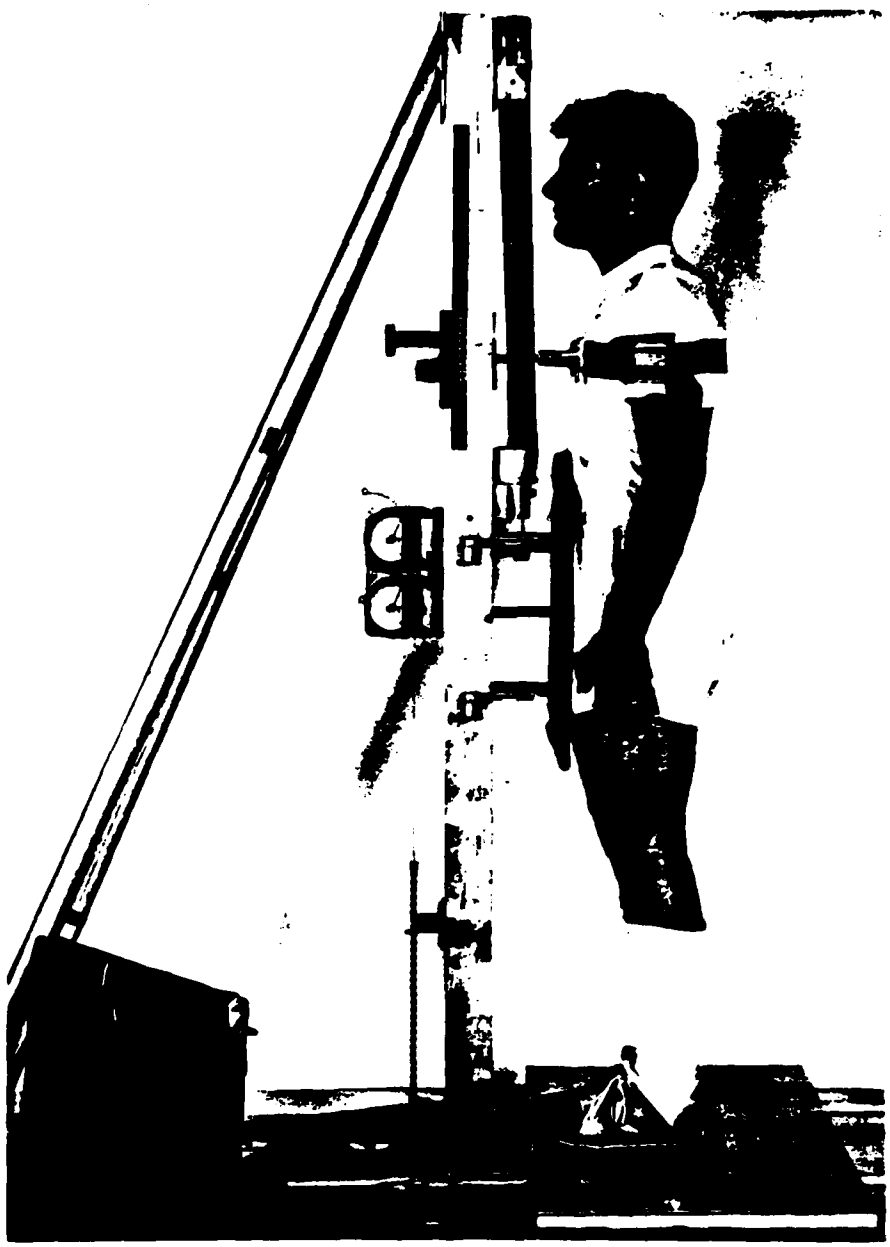


Figure 11. Isometric measurement of trunk extension strength.

TABLE 9. Effect of occupational physical intensity level on maximal oxygen uptake, body weight and body fat.

	Occupational Rating		
	Heavy	Moderate	Light
Group I (Variable Training Intensity)			
n	82	20	40
$\dot{V}O_2max$, $ml.kgBW^{-1}.min^{-1}$**	50.6 ± 6.4	46.7 ± 7.7	47.1 ± 7.5
Body weight kg*	72.2 ±10.0	70.6 ± 9.4	74.5 ± 12.0
Body fat, % of BW*	17.2 ± 5.0	19.6 ± 6.7	19.99± 6.3
Group II (High Training Intensity)			
n	122	62	81
$\dot{V}O_2max$, $ml.kgBW^{-1}.min^{-1}$	53.0 ± 5.0	52.4 ± 5.9	50.5 ± 5.7
Body weight, kg	72.2 ± 10.0	70.6 ± 9.4	74.5 ± 12.0
Body fat, % of BW**	18.7 ± 5.4	18.4 ± 5.5	20.9 ± 6.0

** ANOVA F (<.01)

* ANOVA F (<.05)

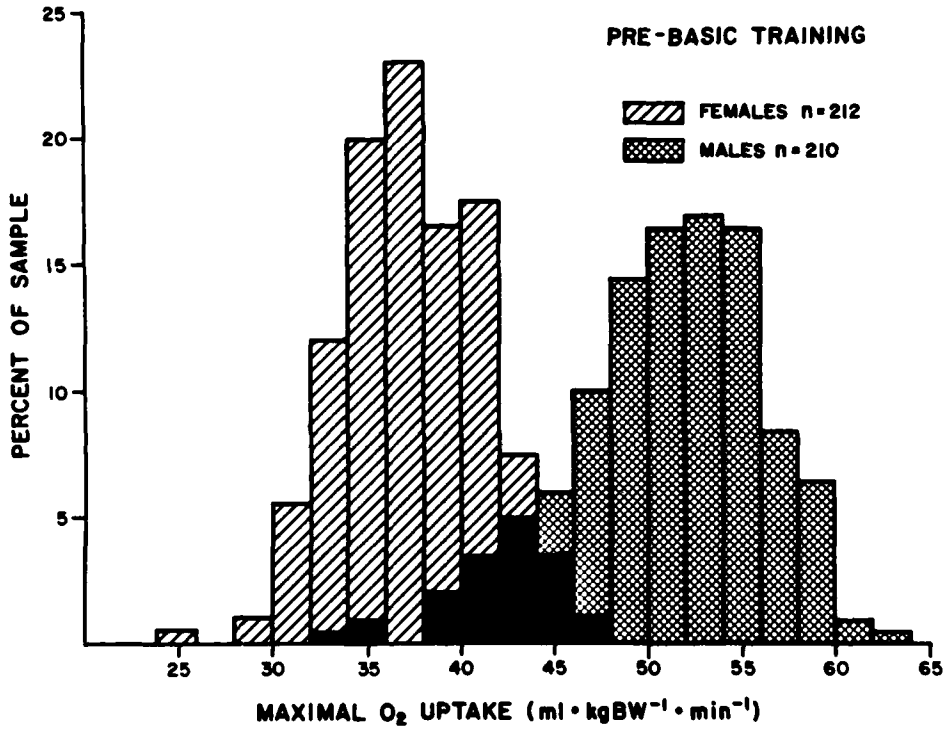


Figure 12. Distribution of $\dot{V}O_2max$ in male and female recruits at the beginning of basic initial entry training (from ref. 10).

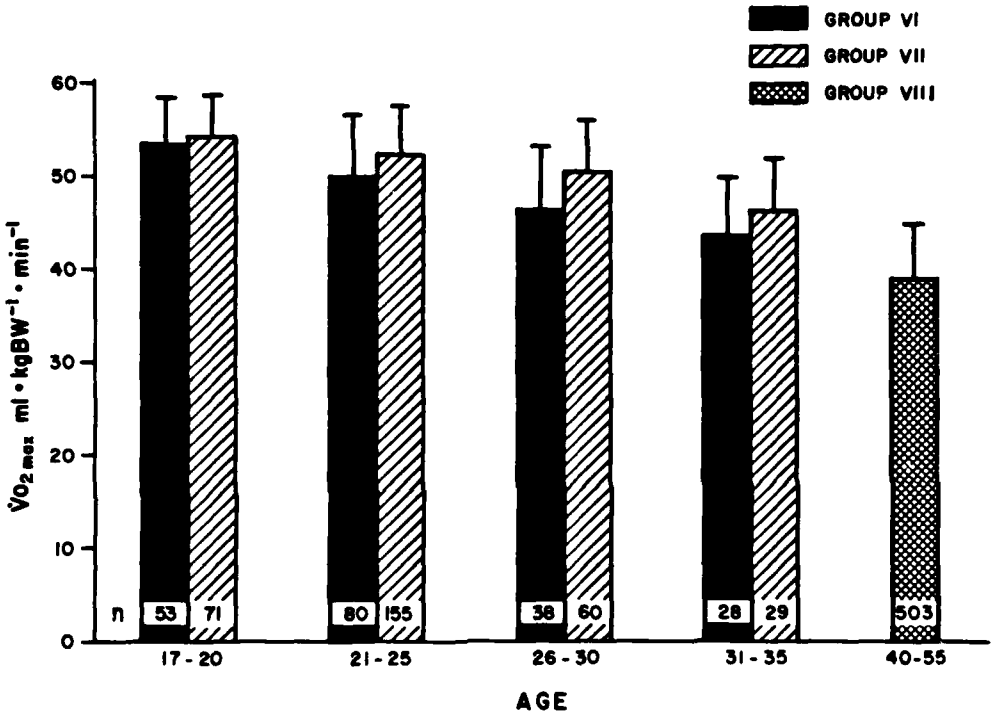


Figure 13. Influence of age on $\dot{V}O_2$max in three groups of male soldiers (from ref. 10). Group VI: untrained, Group VII: trained, Group VIII over 40 age.

low intensity training Army units. Table 9 illustrated the influence of occupational intensity on $\dot{V}O_2max$, body weight and body composition. Table 10 summarizes our most recent Army survey study where $\dot{V}O_2max$ was measured directly on the treadmill. This latter study represents a cross section of a large Army post with a wide variety of units and occupations. Table 11 presents data obtained with the predictive $\dot{V}O_2max$ step test and cycle ergometer procedures in Army recruits.

(2) Anaerobic power/muscular endurance

Considerably less data is available regarding anaerobic power values in Army populations since this has only recently been added to our test batteries .Table 12 summarizes the data from two recent studies on military populations.

(3) Muscle strength

A recent report from our laboratory has summarized muscle strength data from military population samples (11). Tables 13 to 17 give a compilation of data from U.S. military samples. Table 13 presents mean values of isometric strength of various muscle groups while Table 14 presents mean values for peak isokinetic torque of two muscle groups at two different velocities. Tables 15 and 16 give mean male-female comparisons of strength and lifting capacity. The variance in values in male and female samples is presented in Table 17 and illustrated in Figure 14 for lifting capacity to 152 cm.

IV. BODY COMPOSITION

A. Background

TABLE 8. Maximal O_2 uptake, anthropometric and related variables of men and women entering the Army from civilian life, pre-initial entry training.

	Males (n = 210)		Females (n - 212)		
Variable	Mean + SD	Range	Mean + SD	Range	F/M
Age, yrs	19.7± 2.2	17-25	19.7 ± 1.9	17-25	-
Height, cm*	174.7 ± 6.9	153.7-195.1	162.0 ± 6.4	146.7-183.2	-
Body weight, kg*	70.5 ± 10.7	45.8-105.5	58.6 ± 7.0	42.2-77.5	.83
Body fat, % of BW*	15.6 ± 5.6	6.0-32.7	28.4 ± 4.5	12.4-38.8	-
Lean body mass, kg*	59.1 ± 7.0	40.7-80.6	41.8 ± 4.4	32.7-53.1	.71
$\dot{V}O_2$max, $\ell \cdot min^{-1}$*	3.60 ± 0.50	2.31-5.35	2.18± 0.32	1.24-3.14	.61
$\dot{V}O_2$max, $m\ell \cdot kgBW^{-1} \cdot min^{-1}$*	51.1 ± 5.1	32.4-63.7	37.5± 3.7	24.1-47.1	.73
$\dot{V}O_2$max, $m\ell \cdot kgLBM^{-1}$*	60.9 ± 5.6	44.4-79.5	52.4± 5.4	32.0-70.1	.86
HRmax, $beats \cdot min^{-1}$	190.7 ± 6.8	172-210	189.8± 7.4	164-210	-
$\dot{V}_I$max, $\ell \cdot min^{-1}$ (BTPS)*	139 ± 21.3	83.9-194.0	88.6±15.7	46.1-131.7	-

* Mean differences significant at 1% confidence level.

Table 10. $\dot{V}O_2max$ ($ml \cdot kg^{-1}$ body weight$\cdot min^{-1}$) of soldiers assigned to a variety of units and occupations at one Army post (from ref. 4).

	Male			Female		
	n	mean	SD	n	mean	SD
Combined	956	48.0	6.3	240	39.7	4.6
Age						
17-20	126	52.0	4.3	50	41.1	5.3
21-27	332	50.2	5.7	143	39.7	4.0
28-39	275	45.1	5.7	46	38.3	5.3
40+	223	46.0	6.5	-	-	-
Black	213	48.5	6.3	84	38.4	4.1
Hispanic	103	48.0	6.8	17	41.3	4.2
White	603	47.9	6.2	131	40.3	4.7

Table 11. $\dot{V}O_2max$ ($ml \cdot kg^{-1}$ body weight $\cdot min^{-1}$) in Army recruits predicted from the step test and Astrand-Ryhmig procedures (from ref 22

	Males			Females		
	n	mean	SD	n	mean	SD
Astrand-Ryhming Cycle	273	44.3	8.0	274	38.8	7.8
Step test	444	48.3	6.3	387	34.9	5.5

Table 12. Anaerobic power values in male military populations.

Study Reference		Mean	SD	Range	Mean	SD	Range
	Wingate test (mean power, watts)	Upper Body			Lower Body		
7		424	73	301-567	440	101	238-683
27		383	42	312-481	611	57	520-699
	Isokinetic test (mean peak torque, Nm)	Elbow extensors			Knee extensors		
7		23	7	12-52	78	17	52-121
27		19	3	14-25	77	13	58-105

Table 13. Mean isometric strength values in male military populations. Values in kg.

Reference	Subjects	Handgrip	Knee extension	Trunk extension	38cm pull	Horz. arm pull
28	Army recruits n = 102				103.9	
6	Army recruits n = 769		158.2	79.0		
2	Army recruits n = 462	52.6			148.8	
29	Infantry n = 50		161	77		
30	Navy recruits n = 350	46.1				71.1
11	Infantry n = 32	56.2	186.0	89.0	130.6	
31	Navy trainees n = 69	52.2				70.0
32	Infantry	54.0	167.6	80.0	138.0	

Table 14. Mean isokinetic muscle strength values in male infantry soldiers.

		Elbow flexion		Knee extension	
Reference		30°/sec	180°/sec	30°/sec	180°/sec
29	n = 50	56.5	40.5	215.0	178.0
11	n = 32	53.6	41.1	222.5	128.6

Table 15. Male-female mean comparisons of muscle strength in military populations

Reference	Isometric Handgrip (kg)			Isometric Knee Extension (kg)			Isometric Trunk Extension 9kg)			Isometric 38cm upright pull (kg)			Isokinetic trunk extensi at 36°/sec peak torque,N		
	M	F	F/M	M	F	F/M	M	F	F/M	M	F	F/M	M	F	F/
30	46.1	28.5	.62												
32	54.0	34.1	.63	167.6	99.3	.59	80.0	51.3	.64	138.0	83.7	.60	286.9	163.2	
6				158.2	106.6	.67	79.0	56.6	.72						
2										148.8	95.2	.63			
28										103.9	58.3	.56			

Table 16. Male-female mean comparisons of one-repetition maximum lift capacity in military populations.

Reference	Max lift to 132 cm (kg)			Max lift to 152 cm (kg)			Max lift to 183 cm (kg)			Max lift to shoulder height (kg)			Max lift to elbow height (kg)		
	M	F	F/M	M	F	F/M	M	F	F/M	M	F	F/M	M	F	F/M
11	77.7	35.5	.66												
32	57.6	32.5	.56												
2				65.5	34.4	.53	62.1	30.4	.49	50.8	30.2	.59			
23							51.8	25.8	.50				58.6	30.7	.5

Table 17. Values of isometric strength and lifting capacity of Army recruits (Ref 22).

	Male		Female	
	Mean	SD	Mean	SD
	n = 980		n = 1004	
Handgrip, kg.	47.5	7.4	30.2	5.5
38 cm pull, kg.	124.8	21.2	77.1	13.5
IDL 152, kg	60.6	10.7	29.8	5.4
IDL 183, kg	56.7	10.5	25.6	4.7

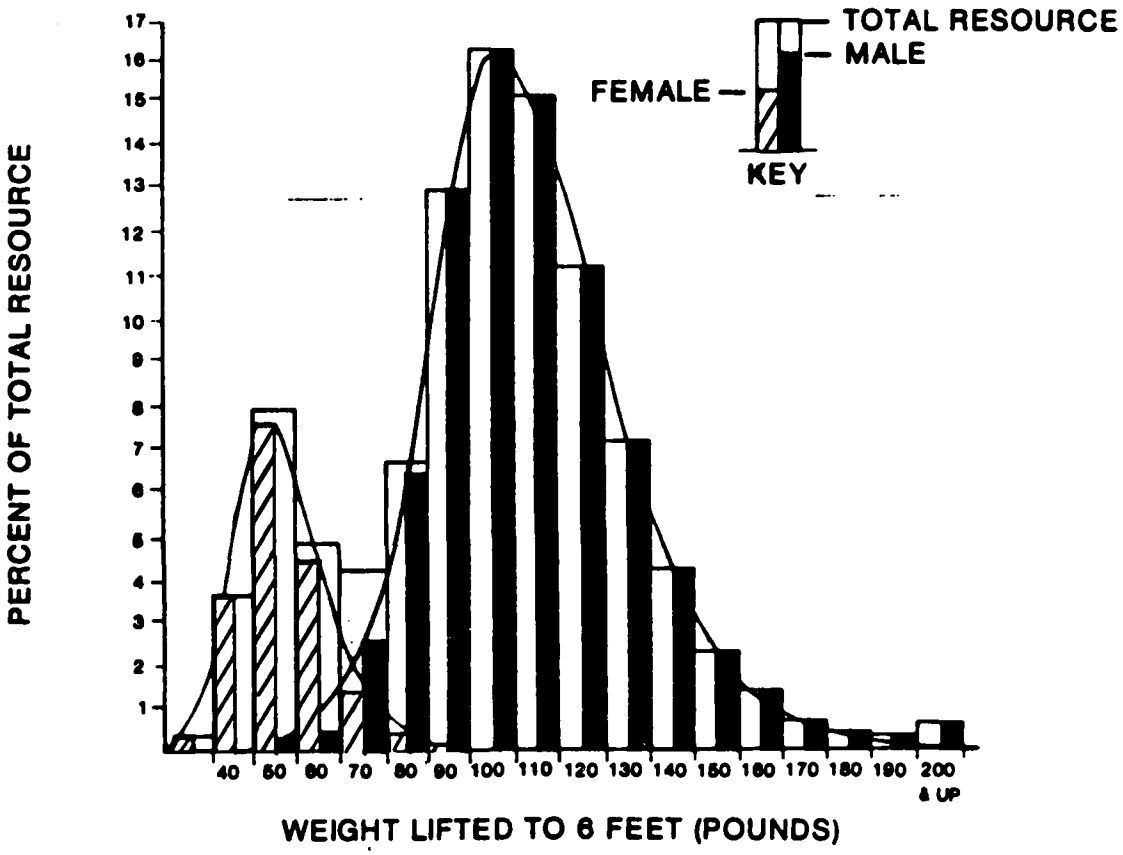


Figure 14. Distribution of lifting capacity to 6 feet in male and female Air Force recruits (from ref. 23).

Body composition in terms of its two main components: fat and fat-free mass, is included in this presentation because of its obvious relationship to fitness capacity and exercise performance. While the relative proportions of muscle and fat have a direct influence on fitness appearance, they also are related to functional fitness capacity and health related fitness. While some degree of body fat stores are necessary as energy sources and mechanical cushioning, excess stores are a burden to the body in that they represent excess weight that must be transported by the active muscle mass. In this respect they detract from the aerobic capacity of the individual when transporting his or her own body weight such as in walking or running. Thus, there is a general relationship between aerobic power adjusted for body weight and percent body fat content as illustrated in Figure 15 (10). Muscle mass, or measurable fat-free mass, is related to strength or anaerobic power capacity since the force that can be generated by a muscle is related to its cross sectional area. Figure 16 illustrates the relationship between lifting capacity and fat-free mass.

B. Methods

Suitable methods for assessing body composition in a "field" (outside the laboratory) setting are of great interest to the military and the topic of considerable recent research. This stems from the importance of the military services' weight control programs to maintain adequate appearance and enhance physical performance. While the Services have traditionally enforced weight control through weight-for-height standards, their limitations were recognized. In 1981 the Services were instructed to supplement these tables with a secondary body fat standard to handle the

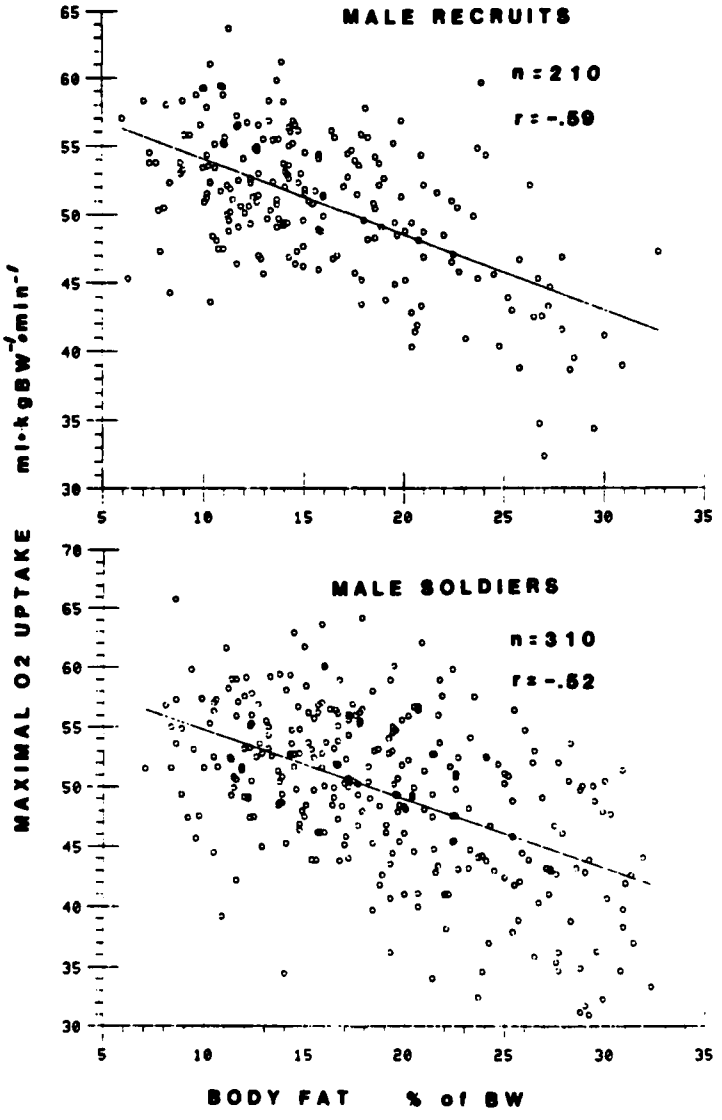


Figure 15. Relation between $\dot{V}O_2max$ (weight adjusted) and percent body fat.

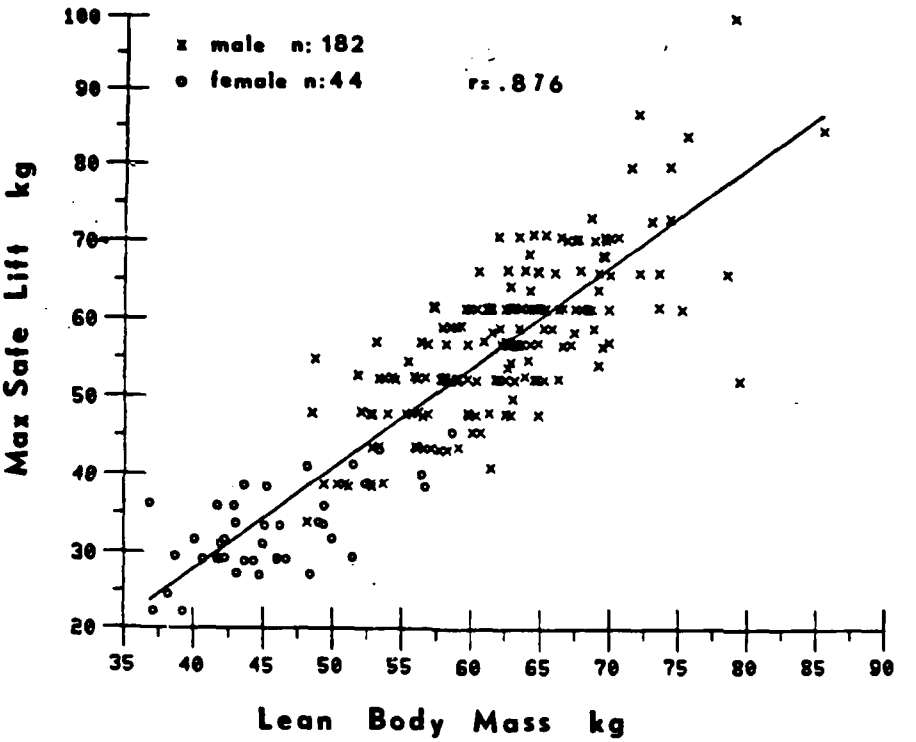


Figure 16. Relation between maximal left capacity and fat-free mass, r=0.88.

over-muscular individual who does not meet weight tables but is not obese. The Army chose to meet this requirement by establishing an age and gender adjusted standard for percent body fat (see table 18). Body fat assessment was performed in medical facilities with the skinfold caliper technique. Of the man skinfold body fat equations available, the Army chose the Durnin-Womersley equations because it is age adjustmented and commonly used by other NATO military services.

The Durnin-Womersley procedure employs four skinfolds: bicep, tricep, subscapular and suprailiac and is represented by the following equations:

$$\% \text{ fat (males)} = \{4.95 - (1.1739 - 0.06227 \times \log 10 \text{ sum of 4 SF}) - 0.000555 \times \text{age}) - 4.5] \times 100$$

$$\% \text{ fat (females)} = [4.95 - (1.1572 - 0.0647 \times \log 10 \text{ sum of 4 SF} - 0.00038 \times \text{age}) - 4.5] \times 100$$

The practical limitation to the skinfold procedure is the potential for large inter-measurer error stemming from variation in site location, extent of pinch and application of calipers. This problem was particularly severe in the Army experience where skinfolds were being performed at about 100 locations with at least that number or more measurers. Even though considerable effort was made to train and credential the measurers, variability was evident and acceptance of the procedure suffered.

Due to these difficulties with the skinfold procedure, it was decided to explore other anthropometric variables that would give adequate

Table 18. US Army maximal limits for percent body fat.

Age category:	17-20	21-27	28-39	40+
Male	20	22	24	26
Female	28	30	32	34

predictability of body fat and could be applied at the unit/organizational level and thereby relieve the medical facilities of this responsibility. Our laboratory carried out a major research project in 1984 to seek such a field procedure. This consisted of hydrostatic weighing and anthropometric measures on nearly 1500 Army personnel. The outcome was the derivation of a circumference technique employing the following equations:

$$\% \text{ body fat (male)} = 46.892 - 68.678 \times \log_{10} \text{height} + 76.462 \times \log_{10} (\text{abdominal-neck circumference}).$$

$$\% \text{ body fat (female)} = -35.601 - 0.515 \times \text{height} + 0.173 \times \text{hip circumference} - 1.574 \times \text{forearm circumference} - 0.533 \times \text{neck circumference} - 0.200 \times \text{wrist circumference} + 105.328 \times \log_{10} \text{body weight}$$

Abdominal circumference is measured at the umbilicus, hip circumference at the largest protrusion of the buttocks and forearm at the largest point (extended). Correlation coefficients and standard error of estimate for the male and female equations are: $r = .817$, SEE = 4.020 and $r = .820$, SEE = 3.598, respectively (4). These circumference procedures and equations will be implemented by the Army in April 1986.

C. Findings

Table 19 summarizes percent body fat values derived by the Durnin-Womersley skinfold procedure for a sample of U.S. Army units. Table 20 presents a summary of our recent hydrostatic weighing data on a large Army

Table 19. Percent body fat values of U.S. Army populations taken by the Durnin-Womersley skinfold procedure.

Reference	Subjects	Age	% Body Fat (mean) Males	Females
8	Recruits - pre		16.3	28.2
33	- post		14.5	26.2
	Recruits - pre	17-20	15.3	27.7
		21-25	16.1	28.8
		26-30	18.1	28.3
		31-35	22.4	31.0
34	Infantry	40-51	26.5	
11	Infantry	17-20	15.8	
		21-25	17.9	
		26-30	19.3	
		31-35	20.0	

Table 20. Percent body fat values in U.S. Army populations by the hydrostatic weighing procedure (mean ± SD) (Ref 4).

Sample	n	Age	% Body Fat	
			Males	Females
Army	160	17-20	16.5 ± 5.6	28.1 ± 5.3
	383	21-27	17.8 ± 6.4	27.2 ± 5.9
	318	28-39	22.8 ± 7.1	30.9 ± 5.8
	258	40+	24.2 + 5.2	-

population along with similar data from the U.S. Navy. The significant age effect on percent body fat is readily observed in these data.

V. PHYSICAL ACTIVITY ASSESSMENT

Assessments of physical activity levels are not routinely made of military populations as is physical fitness and body composition. They are, however, an integral part of research studies concerned with fitness and physical training. Five samples of activity questionnaires that have been employed in our studies are shown in Figure *17.* They are presented as examples. No data are available concerning their validity.

VI CONCLUSIONS AND RECOMMENDATIONS

This chapter reviews the selection of and the methods employed by the U.S. Army to assess physical fitness both in the field and within the laboratory. Representative data from various Army population surveys are presented on new recruits as well as soldiers across a wide age span. The recruit population represents a selected civilian sample, typical of healthy, active young Americans. The data presented here offers a substantial data base which is suitable for comparative purposes with the NCHS General Population Surveys.

Physical fitness assessment, or the measure of functional exercise capacity, is a valuable supplement to health surveys for two reasons. First, it can be considered as an additional level of detection of disease or incapacity where the body is subjected to a load or demand. Thus it increases the chances for detection as compared to examinations carried out

2. ACTIVITY HISTORY: Page 1 of 3

Subject Identification Number _____

Card Number: 02

Test Period: 1

Today's Date (Month, Day, Year): _____

Do you take part in physical activity or sports:

(1) Yes, daily
(2) Yes, Weekly
(3) Yes, Monthly
(4) Yes, occasionally
(5) No

If no, is this because of:

(1) Lack of interest
(2) Ill health
(3) Injury
(4) Lack of facilities
(5) Lack of leaders
(6) Others, specify

If yes, do you take part primarily?

(1) For pleasure
(2) To improve your health
(3) To improve your physical condition
(4) To gain competitive success
(5) Other, specify

Time spent in physical activity, on average?

Hours per day _____ hours
Days per week _____ days

Total hours per week, approx. = _____ hours

When you exercise, select the number which best describes how hard you work out?

7 9 11 13 15 17 19 20

Very, very light Hard Very, very har

Are you a professional or an amateur competitive sportsman?

(1) Full time professional
(2) Part time professional
(3) Full time amateur
(4) Part time amateur
(5) None of these

2. ACTIVITY HISTORY (CONT'D) Page 2 of 3

Subject Identification Number _____

What is your best, i.e. main, sport? _____

What level of achievement have you attained in this sport?

(1) International record holder
(2) National record holder
(3) Member of a national team
(4) Member of state or major district team
(5) Member of a town or city team, etc.
(6) Member of a school, club, or college team, etc.
(7) Other
Give details: _____

At what age did you first:

Play the sport? _____ years
Compete in the sport? _____ years
Achieved your best performance _____ years

What is your second best sport: _____

What level of attainment have you attained in this sport?

(1) International record holder
(2) National record holder
(3) Member of a national team
(4) Member of a state or major district team
(5) Member of a town or city team
(6) Member of a school, club or college team
(7) Other, specify
Give details: _____

At what age did you first:

Play the sport? _____ years
Compete in the sport? _____ *years*
Achieve your best performance? _____ years

2. ACTIVITY HISTORY (CONT'D) Page 3 of 3

How would you compare yourself to others of your own sex and age in terms of physical ability and fitness

(1) Poor
(2) Fair
(3) Average
(4) Above average
(5) Superior

Describe your overall life style in terms of physical activity:

(1) Very inactive
(2) Inactive
(3) Normal
(4) Active
(5) Very active

Did your parents support your participation in competitive sports?

(1) Yes (2) No

(FEMALES ONLY) Do you feel that menstruation interfe with your physical activity?

(1) Yes (2) No

Figure 17. Samples of physical activity questionnaires used in Army fitness research studies.

Sample A

PHYSICAL ACTIVITY QUESTIONNAIRE

1. We are interested in your present "normal" level of physical activity. If you have done any of the activities listed below regularly in the last 6 months, circle the activity and write in the number of days per week you did the activity, and how many minutes on the average you did it on those days. Also, fill in the distance covered (where applicable) and how many years you have done this activity routinely.

	days/week	mins/day	distance/day	no. of yrs involved
walks or hikes	_____	_____	_____ miles	_____
bicycle rides	_____	_____	_____ miles	_____
swimming	_____	_____	_____ yards	_____
running/jogging	_____	_____	_____ miles	_____
calisthenics	_____	_____		_____
weight lifting	_____	_____		_____
karate, judo, etc.	_____	_____		_____
tennis, squash, raquetball, etc.	_____	_____		_____
baseball	_____	_____		_____
basketball	_____	_____		_____
football	_____	_____		_____
soccer	_____	_____		_____
dance	_____	_____		_____
other: _____	_____	_____		_____
_____	_____	_____		_____

2. If there are activities listed above which you have not done regularly in the last 6 months, but have done regularly at other times, please list these activities; how many yrs you did the activity; and what the last year you did it was.

Activity	How many yrs	Last year of involvement (1981, etc)
_____	_____	_____
_____	_____	_____

3. What type of recreational activities do you like best? (For instance fishing, baseball, cooking, pool, card games, etc.)
   1. _____
   2. _____
   3. _____

4. How hard do you usually exercise? Very lightly / Average / Moderately hard / Very hard (Circle one)

5. Did you take Physical Education classes in school? 1. Never / 1 or 2 each week / 3 or more each week

   If yes, when was the last time: This year / 1 year ago / 2 or more years ago (Circle one)

6. Did you take part in school or college sports? Yes / No

   If yes, how many years? 1-2 yr / 3-4 yr / 5-6 yr / 7-8 yr

   If yes, at what level: Unorganized with friends / Organized in school (intramural) competition / Varsity competition with other schools or colleges (Circle one)

   List which sports _____

7. What type of Sports do you prefer? (for instance baseball, running, tennis, etc.)
   1. _____
   2. _____
   3. _____

8. How does your physical fitness compare to others like you? (same age, sex, etc.) Poor / Average / Good / Excellent (Circle one)

9. Is exercise important to your health? Yes / No (Circle one)

10. How do you describe your life? Not very active / Average / Active / Very Active (Circle one)

11. Are your friends involved in sports? Very few of them / Some of them / Most of them / All of them (Circle one)

Figure 17. Sample B

PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in learning about your physical activity patterns. If you have participated in the activities, fill in the number of days/week for the last 3 months.

1. Activities:

	Last 3 months days/wk
Long walks or strenuous hikes	_____
Long bicycle rides	_____
Swimming	_____
Calisthenics	_____
Jogging (running)	_____
Lifting weights	_____
Karate, judo, etc.	_____
Tennis, Squash, Racket Ball	_____
Competitive sports	_____
Dance	_____
Others (List) _____	_____
_____	_____
_____	_____

2. When you exercised, select the odd or even number which best described the intensity (how hard) or your workouts. (CIRCLE ONE)

6		14	
7	Very, very light	15	Hard
8		16	
9	Very light	17	Very hard
10		18	
11	Fairly light	19	Very, very hard
12		20	
13	Somewhat hard		

3. How would you compare yourself to others of your age and sex in terms of physical fitness? (Ability to run, swim, bicycle for long distances.)

1. Poor
2. Fair
3. Average
4. Above average
5. Superior
6. Excellent

4. Did you take physical education or gym classes in:

YES NO Grade School
YES NO Junior High School
YES NO High School
YES NO College

5. Indicate the MAJOR or MAIN reason why you exercised prior to this time (SELECT ONE ANSWER).

1. I do not exercise.
2. It makes me feel good.
3. I am trying to lose weight.
4. It is good for your health.
5. I am required to exercise.
6. My doctor told me to exercise.
7. Other (Explain: _____)

6. Do you believe that exercise makes an important contribution to your overall effectiveness?

1. Almost never
2. Sometimes
3. Often
4. Almost always

7. Have you ever had a physical injury as a result of participating in sports or an exercise program; or have you been unable to participate because of some other injury?

1. YES (Explain: _____)
2. NO

8. Did your father/mother participate in school sports?

Father:	Mother:
1. Yes	1. Yes
2. No	2. No

9. Did you have any older brothers/sisters who competed in school sports?

Brothers:	Sisters:
1. Yes	1. Yes
2. No	2. No

10. Did your close friends in high school take part in sports?

1. Almost never
2. Sometimes
3. Often
4. Almost always

11. Did your parents support your participation in competitive sports?

1. Almost never
2. Sometimes
3. Often
4. Almost always

12. Do you feel that menstruation interferes with your physical activities?

1. Never
2. Sometimes
3. Often
4. Almost always

13. Which of the following best describes your overall lifestyle with respect to physical activity?

1. Very inactive
2. Inactive
3. Normal
4. Active
5. Very active

Figure 17. Sample C

12. PHYSICAL FITNESS: How would you describe your CURRENT level of physical fitness?

A. Excellent
B. Above average
C. Average
D. Below average
E. Poor

13. PHYSICAL ACTIVITY: In regards to physical activity, how would you describe your life (before coming to Parris Island):

A. Very active
B. Active
C. Average
D. Not very active
E. Inactive

14. YOUR OCCUPATION LAST YEAR: During the LAST ONE YEAR, how would you describe the amount of physical activity in your NORMAL DAILY JOB or OCCUPATION?

A. No physical activity: such as unemployed or vacationing

B. Very Light activity: such as student; clerk in an office; mainly sitting at a desk or on a chair

C. Light physical activity: such as service person in a restaurant or store; standing or walking

D. Moderate physical activity: such as construction assistant, housepainter, handyman, mechanic, work involving moderate lifting and carrying

E. Heavy physical activity: such as lifting and carrying heavy objects; using a shovel, pick, or tunnel bar; moving heavy objects (such as heavy furniture); carpentry (with hand tools); or bricklayers assistant

15. SPORTS PARTICIPATION: When you were in high school or college, describe the highest level of your participation in regular sports activities:

A. Seldom or never participated in sports in high school or college
B. Participated in sports on my own or with friends (not organized)
C. Participated in organized sports in school, but NOT on varsity level (example: intramural sports)
D. Participated in sports on a VARSITY team level
E. Participated on an ORGANIZED TEAM outside of school (example: track team or boxing club)

*****

NOTE: The next group of questions apply to your activities over the last ONE MONTH:

*****

15. EXERCISE IN LAST MONTH: Over the last ONE MONTH, how often (ON THE AVERAGE) did you exercise?

A. Did not exercise in the last month
B. Less than once per week
C. Approximately once per week
D. Two to three times per week
E. Four or more times per week

16. CHANGE IN EXERCISE IN LAST MONTH: How did your level of exercise in the last month compare with your usual activity pattern over the past year?

A. I did MUCH MORE exercise in the last month
B. I did MORE exercise in the last month
C. I did about the SAME level of exercise in the last month
D. I did LESS exercise in the last month
E. I did MUCH LESS exercise in the last month

17. JOGGING OR RUNNING: In the last ONE MONTH, how many times did you jog or run (only count the times you jogged or ran for 15 minutes or more without stopping)?

A. Less than 1 time per week
B. Approximately 1 time per WEEK
C. 2 to 3 times per WEEK
D. 4 or more times per WEEK
E. NONE (did not run or jog in the last month)

Figure 17. Sample D

18. DISTANCE JOGGING OR RUNNING: In the last ONE MONTH, when you jogged or ran, how FAR did you normally run:

A. LESS than 2 miles
B. 2 to 4 miles
C. 4 to 6 miles
D. MORE than 6 miles
E. Did NOT run or jog in the last month

19. TIME JOGGING OR RUNNING: In the last ONE MONTH, when you jogged or ran, how many MINUTES did you NORMALLY run?

A. LESS than 15 minutes
B. 15 to 30 minutes
C. 30 to 45 minutes
D. MORE than 45 minutes
E. Did NOT run or jog in the last month

PART III:
ACTIVITIES OVER THE PAST YEAR

Directions: DO NOT enter the answers to these questions on the mark sense answer sheet. Put all answers on this form in the spaces indicated.

*****
The questions in this section apply to your level of physical activity over the PAST ONE YEAR (THE PAST 12 MONTHS).
*****

Directions: Each activity listed below is followed by three (3) blanks. Fill in the blanks as directed below:

NUMBER OF MONTHS: In the first blank, write the NUMBER OF MONTHS during the past ONE YEAR (that is, the past 12 MONTHS) that you did the activity on a REGULAR BASIS. For instance, if you played high school varsity football, you might have played football regularly for 4 months last year.

HOURS PER WEEK: In the second blank, write the number of hours (ON THE AVERAGE) that you did the activity PER WEEK. This means during the months that you did the activity on a regular basis. For example, if you played football (on the average) two hours a day and five days per week, then you played football 10 hours per week during that period.

COMPETITIVE ACTIVITY: If you did the activity in preparation for organized COMPETITION (for example, on a varsity sports team), then put an X in the third column. If the activity was done for fun or to just to get in shape, leave this column blank.

Figure 17. Sample D continued

LEAVE ALL COLUMNS BLANK
for activities that you did NOT do REGULARLY
in the past year.

	How many MONTHS out of the PAST YEAR did you do this as a REGULAR ACTIVITY?	How many HOURS per WEEK did you do this when it was a REGULAR ACTIVITY?	Place an X in this column if the ACTIVITY was done COMPETITIVELY
1. Basketball (non-game)			
2. Stream Fishing			
3. Baseball/Softball			
4. Golf			
5. Volleyball			
6. Calisthenics			
7. Soccer/Lacrosse			
8. Basketball (Game Play)			
9. Racquetball/Squash/Handball			
10. Snow / Water Skiing			
11. Touch Football			
12. Tennis			
13. Ice Skating/Roller Skating			
14. Hunting/Hiking			
15. Swimming (non-competitive)			
16. Bicycling			
17. Aerobic Dancing			
18. Wrestling/Boxing/Martial Arts			
19. Hockey			
20. Competitive Football/Rugby			
21. Gymnastics			
22. Swimming (competitive)			
23. Running			
24. Cross-country skiing			
25. Other: _____			
26. Other: _____			

Figure 17. Sample D continued

We are interested in your present "normal" level of physical activity. If you have done any of the activities listed below regularly in the last 3 months, circle the activity and write in the number of days per week you did the activity, and how many minutes on the average, you did it on those days. Also, fill in the distance covered where applicable.

ACTIVITY	DAYS/WEEK	MINUTES/DAY	DISTANCE/DAY
Walks or Hikes			
Bicycle Rides			
Swimming Laps			
Running/Jogging			
Calisthenics			
Weight Lifting			
Karate, Judo, etc.			
Tennis, Squash, Raquetball			
Baseball			
Basketball			
Aerobic Dance			
Other			

How hard do you usually exercise? (circle one)

Very Light Average Moderately Hard Very Hard

Figure 17. Sample E

only in the resting, non-challenged state. Secondly, it also provides demographic data on the functional capacity of our population that would be useful for a wide variety of employment and industrial related matters.

Surveys of physical fitness should include all three components of exercise capacity: aerobic power, muscle strength and muscular endurance since they represent three distinct energy generating systems and therefore three separate capacities for muscular function. Body composition should also be added since most aspects of fitness must be interpreted in terms of the portions of fat or fat-free mass.

Decisions regarding the selection of fitness measurements are based on a number of considerations including: time and space available, safety, motivation and cooperation required of the participant, and the degree of reliability and sensitivity desired. In our experience in the laboratory setting, indirect or predictive methods of exercise capacity have considerable limitations and have insufficient accuracy and reliability. We have concluded that the dependability and accuracy of direct measurements, even in smaller numbers, outweighs the larger numbers that can be obtained with indirect, predictive procedures. In the case of aerobic fitness, we suggest that actual measurement of oxygen uptake is preferable to estimation from heart rate and that measurements at maximal effort are preferable to those at submaximal effort. In respect to strength and strength endurance, we suggest that actual maximal capacity measurements of lifting, pushing, pulling or cranking, for example, are more meaningful than such measurements as isometric handgrip or elbow flexion force.

A major limitation to the use of direct measurements of exercise capacity in population survey settings is the safety concerns. While the safety of

maximal aerobic testing can be greatly ensured by careful screening and monitoring, the safety of direct measurements of maximal lifting may be more difficult. However, in our experience, the use of equipment such as a weight machine where the body motion can be limited to safe positions and carefully monitored, results in a very high safety level.

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